Young, (metal-)rich and not alone: Formation of thin-disc RR Lyrae stars through binary evolution

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I wish to remember Antonio Sollima. He was one of my "guides" in the early stage of my career during my PhD in Bologna. I learned a lot from him. Thank you, Antonio!

The problem:

- Gaia DR2 revealed (Iorio&Belokurov, 21) the presence of a **population of metal-rich ([Fe/H]>-1, Fig. 1) RR Lyrae in a disc-like configuration and with kinematics consistent with a thin-disc population (Age < 10 Gyr, Fig. 2).**
- This is consistent with previous spectroscopy studies in the solar neighbourhood (e.g. Prudil+20, Zinn+20)
- Such population of kinematically young and metal-rich RR Lyrae is **challenging to explain in the context of classical formation channel of RR Lyrae** (Catelan, 04)

Fig. 1: Photometric metallicity of the Gaia DR2 RR Lyrae. Belonging to the halo-like and disc-like kinematic component

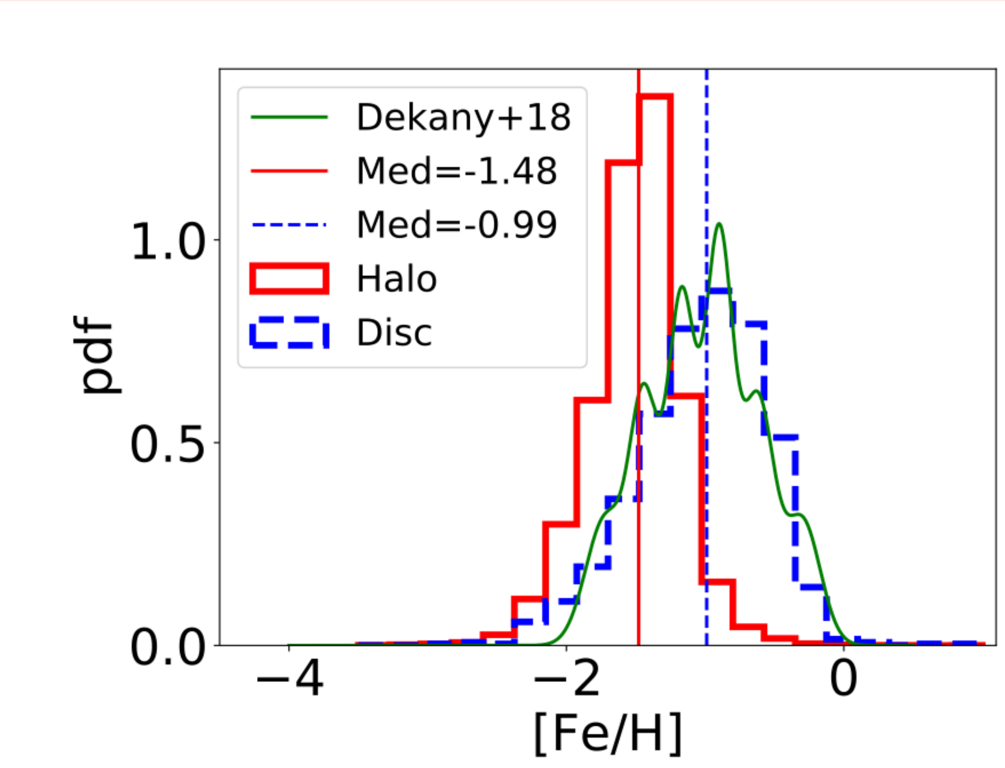
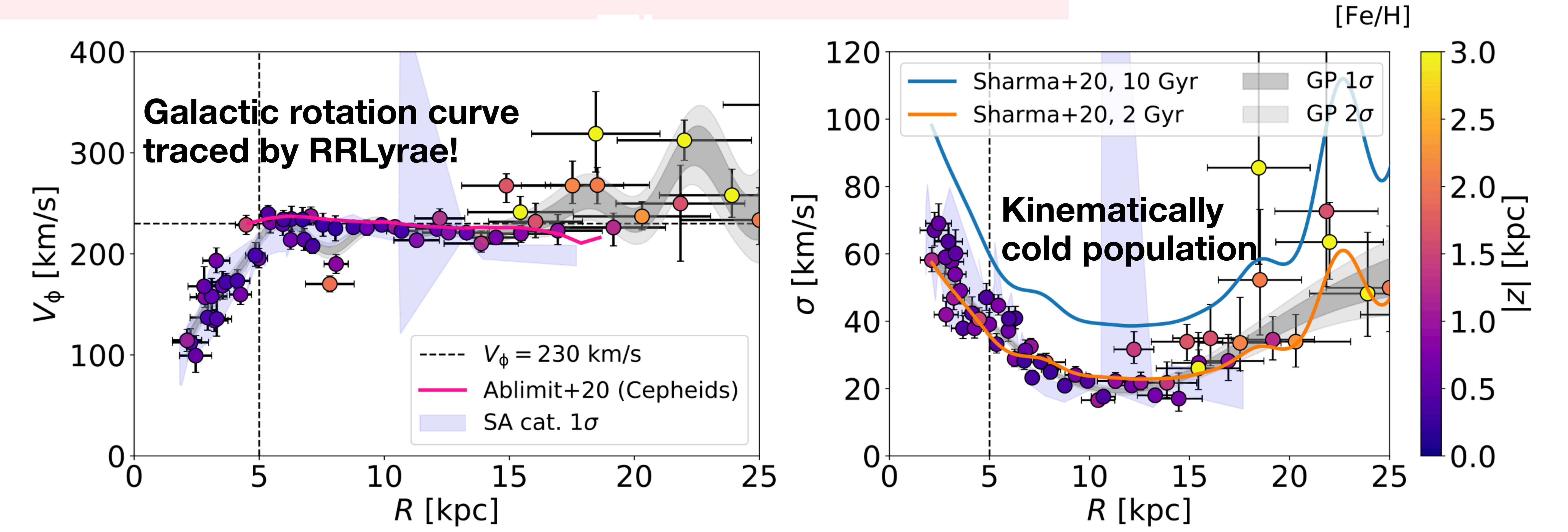


Fig. 2: Kinematic properties f the disc-like RR Lyrae population. Left: Azimuthal velocity. Right: Velocity dispersion.

The magenta line shows the azimuthal velocity as traced by the Cepheids (Ablimit+20). The orange and blue line show velocity dispersion models at different ages obtained by Sharma+20 analysing a population of disc stars.



A possible solution:

In Bobrick&Iorio et al., 2022, we explore the possibility that binary mass transfer can produce young and metal-rich RR Lyrae. We performed detailed binary evolution simulations by using the code MESA (Paxton et al., 2019). Then, we make predictions for the Galactic population using the Besançon Galactic model (Robin et al., 2003).

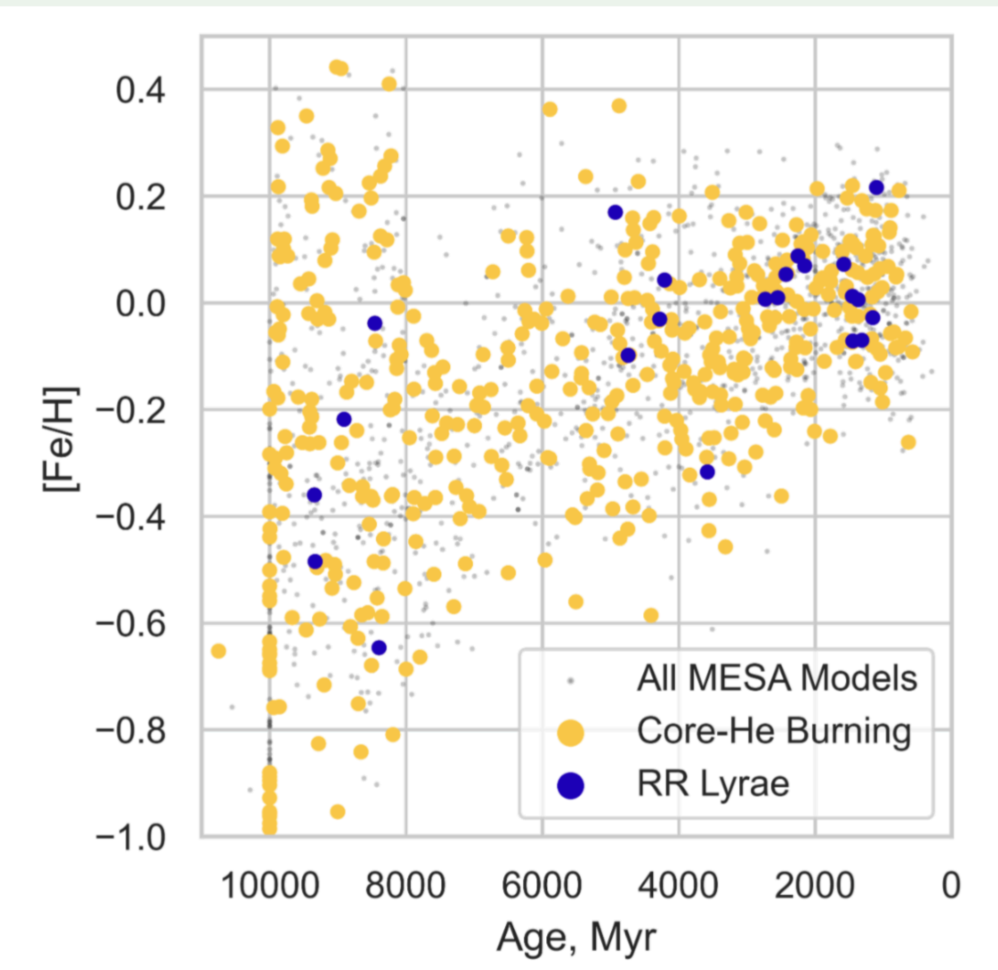


Fig.3: Properties of the core-helium burning stars formed after episodes of binary mass stripping in our simulations (Bobrick&Iorio et al., 2022). The blue dots shows the stars that end in the RR Lyrae instability strip.

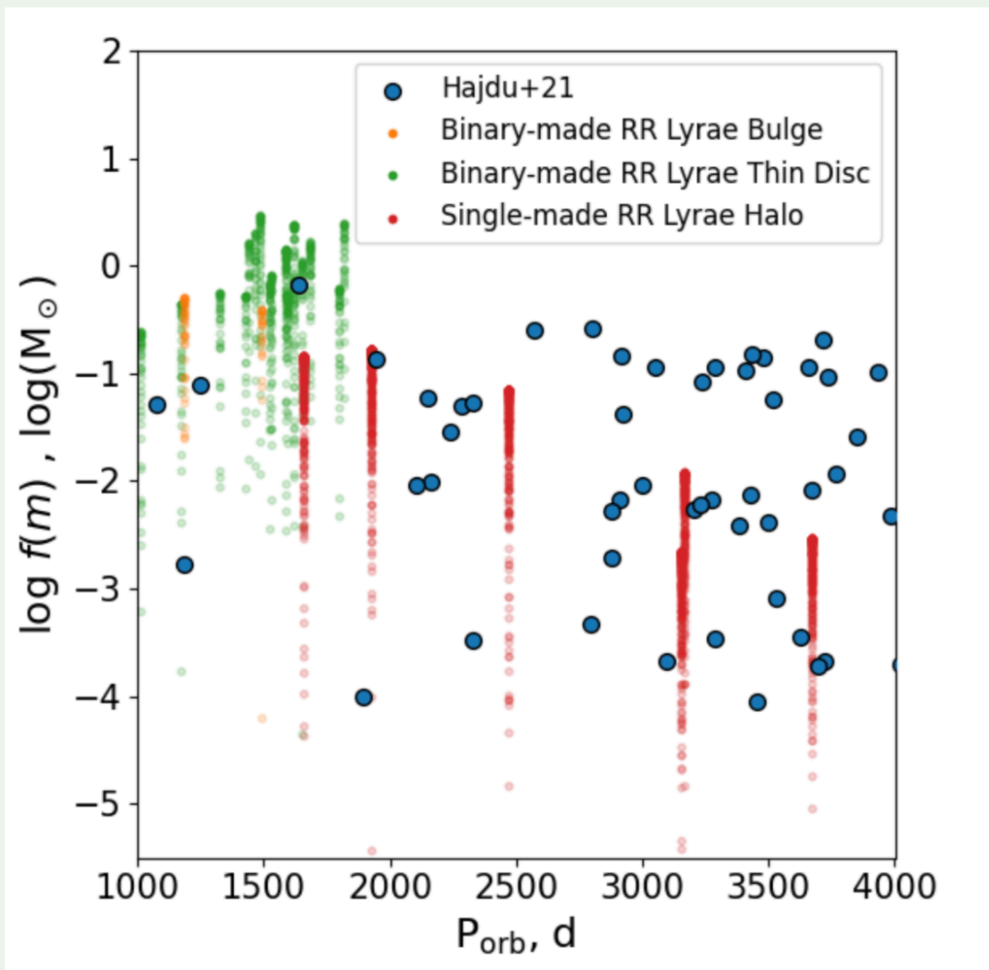


Fig.4: Comparison between the binary RR Lyrae candidates from the Hajdu et al., 2021 sample (blue) and the binary RR Lyrae from our simulations. The x-axis reports the orbital period, while the y-axis the mass function f(m), a combination of the stellar masses and the inclination of the binary. The points from the simulations show: RR Lyrae formed through binary mass transfer in the bulge (orange) and in the disc (green) and RR Lyrae formed through single stellar evolution but in a non-interacting binary system in the stellar halo (red). Since the mass function f(m) depends on the binary inclination, for the simulated binaries we sample 1000 random inclination assuming an isotropic distribution.

- **Mass transfer in binary systems is capable to produce young (2-9 Gyr) and metal-rich ([Fe/H]>-1) RR Lyrae (Fig. 3). THIS IS A STRONG PREDICTION OF STANDARD BINARY EVOLUTION MODELS.**
- We predict that such **RR Lyrae stars should be today in binary systems with orbital periods in the 1000-2000 days range. Have we seen them? Not yet, but candidates from Hajdu+21 seem to be consistent with the model expectations (Fig. 4).**
- Binary mass transfer is a promising channel to produce young RR Lyrae, but still **a lot of work is needed to confirm or reject this hypothesis.**

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